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Smart energy meter with GSM card recharge

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Abstract

The objective of the project are to reduce delays at energy metre billing counters and automatically limit energy meter usage, if the bill is not paid. The study also seeks to provide a mechanism that will lessen the amount of money lost to power theft and other illicit activities. The method of work takes a completely novel idea for a "prepaid energy meter." GSM technology is employed in order for the customer to get notifications regarding your power usage (measured in watts); if it hits the minimum, it would immediately notify the user that they require a recharge. This method works well for distributing various kinds of electricity. Businesses, exclusive areas, IT parks, and self-contained home developments. Prepaid electricity billing systems that use GSM-based communication address problems with metering and billing faults that result in revenue loss for the Nigerian power sector. This creative approach reduces errors in meter reading caused by human error, electro-mechanical

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metre imperfections, and payment processing issues. It is widely used to guarantee accurate invoicing, eliminate past-due bills, and increase utility revenue.

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1. Introduction

The global increase in energy demand and the urgent need for sustainable practices have forced us to reassess how we use electricity. Traditional energy metering systems are deficient in accuracy, user involvement, and remote management. This study presents a revolutionary solution: the smart energy meter with smart card and GSM recharge. Through the integration of smart cards, GSM connectivity, and smart energy metering technologies, this system offers real-time insights into energy usage. Intelligent cards safely store information, and cutting-edge sensors precisely measure usage. Because they can access their consumption data, users are better equipped to make informed decisions [1].

The primary objectives of a smart energy meter with GSM card integration are to revolutionise and enhance the efficiency of energy management systems. By implementing a prepaid system by employing GSM cards, this technology seeks to give consumers continuous control and monitoring over their energy consumption. Ensuring transparency in energy spending is the aim to empower users to make educated decisions regarding their consumption. Predictive disconnections upon credit exhaustion inhibit excessive usage and facilitate accurate invoicing. User convenience is prioritised with timely low credit alerts and remote recharge capabilities via SMS or other GSM means. Strong security protocols protect user data, and the addition of a microcontroller-based system improves billing process accuracy and operating efficiency. A smooth integration into the larger energy grid is ensured by interoperability with the current infrastructure. Through the promotion of sustainable practices, responsible use, and the integration of GSM technology, smart energy meters with GSM card integration aim to establish an eco-friendly. Economic and user-friendly approach to energy management [2] and [3].

2. Literature Review

Literature review involves exploring existing research, publications, and academic work related to the integration of smart metering technology

with GSM capabilities and prepaid card recharge systems. Here is a brief overview of the key themes and findings from relevant literature:

The literature reviews the concept of prepaid recharge systems for energy meters, particularly those of GSM enabled smart cards. Prepaid systems offer consumers flexibility in managing their energy usage and expenditures. Studies may highlight the benefits of prepaid models, such as reduced financial burdens on consumers and improved revenue collection for utility providers [4].

Literature often begins by discussing the evolution of smart metering technology. Smart meters are characterized by their ability to provide real-time data on energy consumption, enabling better management of electricity distribution. The advantages of smart metering include improved accuracy, reduced operational costs, and enhanced consumer awareness of energy usage patterns [5][6].

Researchers explore the integration of GSM technology with smart meters to enable remote communication. GSM facilitates two-way communication between the smart meter and a central server, allowing for realtime data transmission, remote monitoring, and control. This integration is seen as a key enabler for advanced functionalities in smart grid systems [7].

Research on protection of system from ground fault in a smart energy system refers to an unintended electrical connection between the system's conductive components and the ground (earth). Here is how a ground fault might manifest in a smart energy context and some potential consequences. So, there will be a need of ground fault protection and over voltage protection [8].

3. Proposed Design

A. *Operating Principles*

a) Overview of smart meter: The Smart Energy Meter with GSM card technology is a groundbreaking alternative to traditional energy management that runs on a prepaid basis. By acquiring GSM recharge cards, users can prefund their accounts and provide transparency in the monitoring of electricity. The meter offers real-time energy tracking made possible by GSM connectivity, encouraging prompt awareness and conscientious use. Accurate billing and reduced delinquent bills are ensured by an automatic disconnection mechanism that activates when prepaid credit is depleted. While

remote recharge options through SMS or other GSM means give flexibility for consumers and utility providers, low credit alerts make timely recharges easier. Encryption, strong security, and a system based on a microcontroller improve operational effectiveness and facilitate the shift to more sustainable, safe, and responsible energy management.

b) Basic Operating Modes: There are two main ways of operation for the Smart Energy Metre with GSM card. When in consumption mode, it continuously tracks the amount of energy used in real time and deducts prepaid credits as necessary. The metre alerts customers when the prepaid amount is about to run out by switching to a low credit alert mode. When the user recharges the GSM card, an automatic disconnection mechanism in the disconnection mode occurs, temporarily cutting off the electrical supply. This ensures responsible and effective energy management.

c) Control Techniques: Smart energy meters that include GSM cards use cutting-edge control strategies to provide effective energy management. These metres use GSM technology to provide real-time data exchange, remote monitoring, and control. Prepaid systems allow users to control their use more transparently. When credit runs out, automatic disconnections stop abuse and guarantee accurate invoicing. Alerts about low credit allow users to recharge on time and more conveniently. Control methods are now integrated with GSM cards, which is a big step towards responsible and responsive energy use and the development of a more user-friendly and sustainable energy ecosystem.

B. *Design Consideration*

GSM Technology Integration: Include GSM modules to provide communication between the utility company and the smart meter, allowing for remote control, monitoring, and recharging capabilities. Prepaid System Architecture: Utilising GSM recharge cards, consumers can pay for power in advance while using prepaid system architecture in meters.

Real-time Data Processing: To enable continuous recording of energy usage and real-time data processing, reduce the need for manual labour by putting in place a sturdy microcontroller-based system.

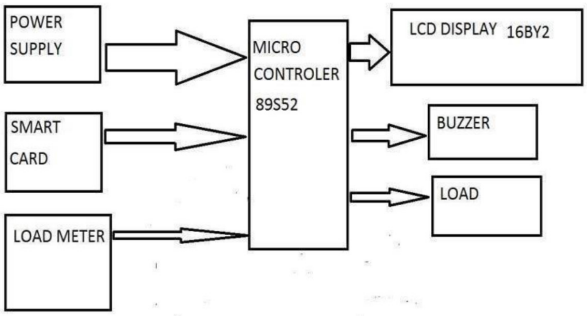

Figure 1

Block Diagram of Smart Energy Meter with GSM Card Recharge

Safe Data Transmission: To guarantee the safe transfer of data between the meter and utility servers, give cybersecurity top priority and have strong encryption mechanisms in place.

Automatic Disconnection Mechanism: When the prepaid credit runs out, a relay-based automated disconnection mechanism will kick in to stop further electricity use until the card is recharged by the user.

Low Credit Alerts: Include a notification system that lets customers know when their prepaid credit is about to expire. This will help users recharge their cards on time and avoid service interruptions. User-friendly Interface: Create a smart metre with an easy-to-use interface that gives users quick access to warnings, recharge status information, and real-time consumption data.

Remote Recharge Functionality: Enable utility suppliers to remotely recharge prepaid cards via GSM/SMS modes in response to consumer requests. This feature would improve user comfort and minimise manual intervention.

Figure 1 Shows the block diagram of the system and components are used in the system like microcontroller 89s52, load, buzzer, lcd display (16*2), supply, relay, smart card, and load meter. Every Component has their own importance in the system and every component work under rating Value.

Figure 2 shows working of energy meter through a flowchart when system is start then GSM card Module is initialized to check balance if the sufficient balance is available then power consumed by the load until the balance becomes zero, Thereafter the power is cut. When the balance is insufficient the buzzer works &give a single to recharge the card then the system starts working again.

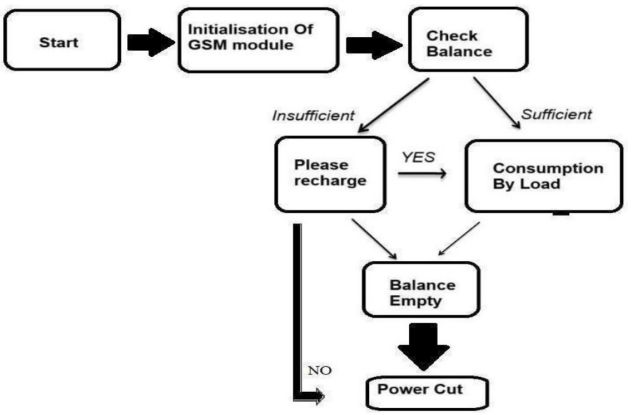

Figure 2

Flowchart for Working of Smart Energy Meter with GSM Card Recharge

The hardware prototype of the system is shown in Figure 3.

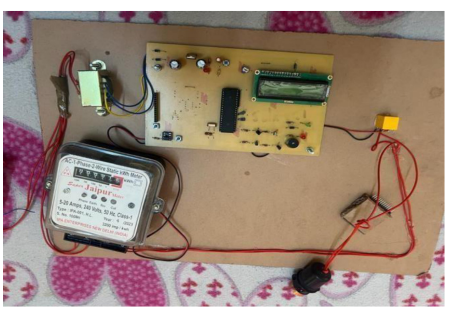

Figure 3

Hardware Prototype of Energy Meter with GSM Card Recharge

C. *Performance Characteristics*

A Smart Energy Meter that uses GSM recharge cards has several important performance qualities that make it a useful tool for contemporary energy management. Here are the key points:

Prepaid System Efficiency: By enabling a prepaid system and allowing consumers to pay for electricity in advance, GSM recharge cards improve efficiency.

Real-Time Consumption Tracking: Real-time tracking of energy consumption is possible with smart energy meters, giving consumers immediate insight into their usage habits.

GSM Communication: The utility provider and the meter can communicate seamlessly when GSM technology is used. This makes it possible to monitor, control, and recharge remotely. Credit Based Usage: Recharge card users use power while keeping a credit balance on the card until the balance is exhausted. This credit-based usage approach encourages increased energy awareness and control. Automatic Disconnection on Depletion: Upon depleting the prepaid credit, the meter automatically disconnects via a relay, prohibiting additional consumption of electricity until the card is recharged. Low Credit Alert: When a user's prepaid credit is about to run low, the system can notify them in a timely manner so they can recharge and prevent service interruptions.

Remote Recharge Capability: In response to consumer demands, utility companies can remotely reload the prepaid card via GSM/SMS modes, saving customers time and minimising the need for manual interventions.

Microcontroller Based System: The metre performs better when a microcontroller is integrated because it continuously records and processes consumption data, which decreases the need for manual labour and improves billing accuracy.

Reduction of Revenue Loss: The prepaid system has successfully reduced revenue loss by minimizing errors in processing, billing, and human metre reading when combined with GSM technology. Promoting Energy Conservation: Real-time data transparency and the prepayment model incentivize customers to be more energy-aware, which advances general energy-saving initiatives. Potential for Tariff Incentives: By enabling tariff or nontariff incentives, the system further promotes energy efficient practices and encourages the voluntary use of smart energy meters.

D. *Hardware Characteristics*

A smart energy meter with GSM card recharge typically incorporates several hardware characteristics to enable its functionality

Energy measurement module:

Accurately measure energy usage with precision measurement components (such as voltage dividers and current transformers).

To process and compute energy data, use a microcontroller or specialised energy measurement integrated circuit.

Communication Module:

The Global System for Mobile Communication, or GSM, module for wireless connections with utility provider servers is the communication module. antenna used for GSM network data transmission and reception.

Mechanisms for secure communication to guarantee the confidentiality and integrity of data.

User Interface:

Real-time energy use, balance, and other pertinent data can be shown on an LCD or LED display. Touch interfaces or buttons allow users to interact and navigate menus.

Recharge Mechanism:

GSM SIM card slot for replenishing the energy balance and communicating with the utility company. Protocols for encrypted and secure communication are used to handle recharging transactions.

Power Supply:

A dependable power source that can withstand power outages by combining backup batteries and mains power to maintain continuous operation.

Processing Unit: Device control, utility provider communication, and data processing are handled by a microcontroller or microprocessor.

Data storage: Non-volatile memory, like Flash memory, used to store configuration options, usage statistics from the past, and other pertinent data.

4. Result & Conclusion

Efficient real-time energy monitoring, remote recharging capabilities, and an intuitive user interface are the main goals when designing a smart energy metre with GSM card recharge. Device security is increased via tamper detection, secure communication through the GSM module, and a dependable power source. A comprehensive and efficient smart energy meter includes compliance with standards, data logging for analysis, remote firmware updates, and optional environmental monitoring.

The Global System for Mobile (GSM) technology used in the creation of the Smart Energy meter enables consumers to pay for electricity before

it is used. Customers use credit in this manner, holding it until the credit runs out or expires. A relay cuts off the electrical supply if the credit limit is reached or expires. Additionally, a plan is put in place to alert the user when their balance credit drops with the aid of a Global System for Mobile (GSM) communication module. This method has been put forth as an original and imaginative response to the issue of utility system affordability. Since the system is based on a microcontroller, the readings can be continually logged. As a result, it lessens the need for human effort while also improving the efficiency of how electricity bills are calculated. Prepaid smart energy meters are a good way to raise awareness about needless power waste and will help to cut down on power waste. This Smart Energy Meter module will ease the load on energy providers by making connections quickly and preventing power theft. By providing tariff or non-tariff incentives to customers who prepaid their power changes, it encourages customers to choose smart energy meters (prepaid) voluntarily. This will assist utilities in implementing smart energy met.

5. Challenges and Limitations

Although they hold great promise for improving energy management, smart energy meters have several drawbacks. The first deployment cost is a major worry since it can prevent widespread adoption, especially in underdeveloped areas. Another difficulty is the infrastructure needed for smart meters, which includes data management and communication networks. This is particularly true in isolated locations with spotty internet. Different energy sector standards lead to interoperability problems that impede smart metre inclusion into current systems. Because of these gadgets' growing connectedness, which leaves them vulnerable to hacking and unauthorized access, security and privacy concerns are critical. Data protection for customers and security of the electricity grid become top concerns. Moreover, utilities have operational difficulties because of the complexity of switching from conventional to smart metering systems. Widespread adoption may be hampered by customer resistance motivated by worries about data security, privacy, and possible health effects of radiofrequency emissions. Moreover, some energy customers, including small families with consistent usage patterns, may not be good candidates for smart meter adoption, which could reduce the overall cost-effectiveness of the technology. There are a few obstacles that smart energy meters must overcome, such as expensive upfront expenditures, restricted infrastructure, cybersecurity concerns, interoperability problems, resistance from consumers, and suitability for specific user demographics.

Realizing the entire potential of smart meters to transform energy management requires addressing these issues.

6. Future Development

Wi-Fi module integration presents a big opportunity for future advances in GSM smart card-based smart energy meters. With the help of Wi-Fi module, the card can be recharge from anywhere.

A ground fault in a smart energy system refers to an unintended electrical connection between the system's conductive components and the ground (earth). Ground faults can occur in both traditional and smart energy systems. Here is how a ground fault might manifest in a smart energy context and some potential consequences. So, there will be a need of ground fault protection and over voltage protection will also play important role in future development.

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